Original Research Article

A Method to Select Plus Tree for Flower Purpose in Forestry

PhungDinh Trung[1], Tran Duc Manh[1], Nguyen Toan Thang[1], Dang Van Thuyet[1], Dao Trung Duc[1], Mai Thi Linh[1], Nguyen Van Tuan[1], Nguyen Thi Thu Phuong[1], Ninh Viet Khuong[1], Tran Hoang Quy[1], Tran Cao Nguyen[1], Dang Thi Hai Ha[1], Vu Tien Lam[1], Nguyen HuuThinh[1], Hoang ThanhSon[1], Trinh Ngoc Bon[1], Ho TrungLuong[1], Ly ThiThanh Huyen[1], Hoang Van Thang[1], Vu Van Thuan[2], and Tran Van Do[1]*

[1]Silviculture Research Institute, Vietnamese Academy of Forest Sciences, Hanoi, Vietnam

[2]Centre for Applied Silviculture Research and Extension, Silviculture Research Institute, Vietnamese Academy of Forest Sciences, Hanoi, Vietnam.

[*]For Correspondence: E-mail: dotranvan@hotmail.com

Author's contributions

This work was carried out in collaboration among all authors. Author TVD, PDT, TDM, NTT, DVT, DTD, MTL, NVT, NTTP, NVK, THQ, TCN, DTHH, VTL, NHT, HTS, TNB, HTL, LTTH, and VVTconducted a field survey and data analysis. Author TVD managed the literature searches, performed the statistical analysis, and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

ABSTRACT

Plus tree selection is the first step to improve production and quality in forestry. An individual-based method is widely used to select plus trees for timber production, timber form, freedom from diseases and insects. In this study, a method to select plus trees for flower production is described and named as a crown-area-based method. Both individual-based and crown-area-based methods were used to select plus trees for *Camellia impressinervis*, a golden camellia; its yellow flowers have been used to treat sore throat and diarrhea, and to prevent cancersin China and Vietnam. Flower production of 21 concerned individuals was compared to the population mean and it was generated as a percentage. The population mean of the individual-based method is the mean of production of 21 trees as mean production/tree. While population mean of the crown-area-based method is mean production/m^2 crown area (first production/m^2 crown area for each tree was generated, then mean for population). The results indicated that both methods show seven individual trees with flower production >100% population mean. However, individual trees are different. Only five of 7 trees are the same in both methods. The tree rankingsby flower production percentage in both methodsare totally different. The highest ranking by individual-based method (310% mean) is 4^{th}ranking by crown-area-based method (181% mean). While the highest ranking by crown-area-based method (270% mean) is third ranking by individual-based method (260% mean). It is concluded that crown-area-based method is better in selecting plus trees for flower purpose, as it considers the crown area which is known as a productive part of a tree to form flowers.

Keywords: Crown-area-based method; Flower production; Golden camellia;Individual-basedmethod; Population mean.

1. INTRODUCTION

Tree breeding is a key element in the improvement of production and timber quality in forestry.While plus tree selection is the first important step in an improvement programme[1]. Trees, that meet requirements/characteristics of foresters such as growth rate, timber form, freedom from diseases and insects, and resistance to/or recovery from snow and ice breakage, are called plus trees. Therefore, if a tree is not sufficiently outstanding to strike the attention of the experienced forester who is subconsciously looking for such trees, it probably is not a plus tree. Selection of plus trees will require the cooperation of forest-products technicians, but the forester should be aware that local industries may have some knowledge of quality variation in the species they are processing [2].

Selecting plus trees in forestry has been widely applied mainly for the purpose of timber production [1, 3], cone production [4-5], disease and insect resistance [6]. However, such plus tree selection for flower purpose is still a gap. There is a number of desirable characteristics, which foresters prefer in plus tree selection. However, it is suggested that only one or two characteristics should be included in a plus tree selection such as timber production and quality; growth rate and timber form; disease and insect resistance. In plus tree selection, (1) environmental variation must be minimized, (2) current periodic data on desirable characteristics should be used other than long-term data, (3) the difference between the plus tree and the mean of a part or all of the stand should be large, and (4) a large number of plus trees should be selected [2].

*Camellia impressinervis*Hung T. Chang & S. Ye Liangis known as a golden camellia [7-10], which has natural distributions in Southern China and Northern Vietnam. The species is classified as an evergreen shrub or small-sized tree, which may reach up7 m tall at maturity (Fig. 1). *Camellia impressinervis*naturally distributes in evergreen broadleaved forests [11]. *Camellia impressinervis*has yellow flowers of up to 6 cm in diameter. The main product is dry flower. Several studies indicated the importance of using golden camellias flowers on antioxidant activities, superoxide anions, and hydroxyl free radicals scavenging assays [12-13]. Traditionally, flowers of golden camellias are used to treat sore throat, diarrhea, and cancer prevention in China and Vietnam[14]. In a population of *C. impressinervis*, there is a high variation of flower production among plants; a 1.2 m tall tree of *C.impressinervis* can bloom up to 130 flowers in a year [15], while other plants of the same size may have less than 10 flowers.Currently, market price of golden camellias is 600-700 US$/ 1 kg dry flowers in Vietnam [11]. Therefore, selecting plus trees for flower purpose and applying vegetation propagation [16] are necessary for intensive plantation establishment of *C.impressinervis*.

The objectives of this study are to describe a method for selecting plus tree of flowers and to apply the method for selecting plus trees of *C. impressinervis* – a golden camellia in NorthernVietnam.

Fig. 1. Plantedtree (left), flower buds (middle), and flower (right)[photographed by authors Duc DT and Son HT]

2. MATERIALS AND METHODOLOGY

2.1 Method for Selecting Plus Tree of Flowers

For flower and fruit trees, a crown/canopy is known as a productive part of a tree. The canopy represents branches, leaves to create buds for flowering and fruiting. Therefore, it must be central to consideration other than stem diameter as selecting plus trees for timber production.

Flower production of any plantation is identified as tons/ha/year. It depends on planting density and production of panted individual trees. Assuming that trees are old enough and they flower stably. Thereforeindividual-basedproduction is not changing year by year if there is no change of climate condition and trees are tended similarly. There are two individual trees (B and C) in a population. Of which B individual has a crown area (C_a) of 1 m^2 and C individual has C_a of 2 m^2 (Fig. 2). While B individual has flower production of 1 kg/year and C individual has flower production of 1.5 kg/year. Individual-based plus tree selection indicates that C individual has flower production of 1.5 times of B individual. Therefore, C individual must be selected as plus tree. Meanwhile, crown-area-based plus tree selection indicates that B individual (1 kg/m^2/year) has flower production of 1.33 times of C individual (0.75 kg/m^2/year). Therefore, B individual must be selected as plus tree (Fig. 2).

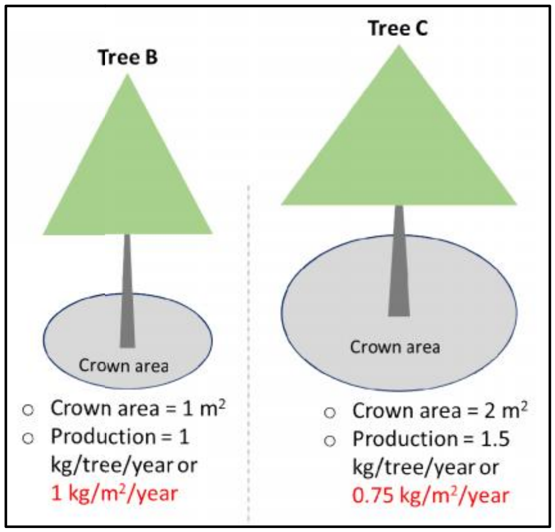

Fig. 2. Plus tree selection point of view

2.2 Study Site

Camellia impressinervis naturally distributes in Southern China and Northern Vietnam [3, 7-8]. *Camellia impressinervis* was recorded to be planted in Thach An district, Cao Bang province, Northern Vietnam [11]. It was planted personally by local people in their gardens.Therefore, this study was conducted at a plantation in Thach An district(22°24'56.8'', 106°25'23.9'').Data collection was permitted by plantation owners.

2.3 Data Collection and Analysis

Interviewing plantation owner indicated that size of flowers from all individuals is similar, which are not depending on tree sizes (Fig. 1). Flower production assessed through the number of flowers produced was the criterion for selecting plus trees, which was applied in other [4]. Plantation of *C. impressinervis*, which is mature and flowers stably by interviewing owners, is selected for data collection. The number of flowers of each individual is counted carefully. Tree height, stem height under the crown (H_{uc}), stump diameter (D_o), and crown diameter (D_c) are measured for all trees.

There are two ways of calculation includingindividual-based method and crown-area-based method. In the individual-based method, average flower number of all individuals in a population is calculated as the population mean. Then, the percentage of individual flower production(per individual base) compared to the population mean is generated. While in crown-area-based method, first flower number per m^2 is calculated for each individual; population mean flower number per m^2 is calculated based on data of all individuals; then, percentage of individual flower production (per m^2 base) compared to the population mean is generated. All analyses were conducted using SAS 9.2 (SAS Institute Inc., Cary, NC, USA).

3. RESULTS

Growth parameters and a number of flowers of 21 trees in this study were recorded (Table 1). The number of flowers ranged 9-186 flowers/tree/year. Their stump diameters (D_o) ranged 1.2-12 cm, stem height ranged 1-4 m, stem height under crown ranged 0-0.7 m, and crown diameter (D_c) ranged 0.7-2 m. Crown areas of recorded trees ranged 0.4-3.1 m^2/tree and number of flowers/m^2 ranged 6.2-138 (Table 1).

Table 1. Growth parameters, number of flowers (No. flowers), and tree rankings following individual-based method and crown-area-based methodof 21 survey trees

No	No. flowers / tree	D_o (cm)	H (m)	H_{uc} (m)	D_c (m)	Crown area (m^2)	No. flowers / m^2	Individual-based method (%)	Crown-area-based method (%)
1	156	4.0	1.4	0.6	1.2	1.1	138.0	260	270
2	80	2.2	1.3	0	0.9	0.6	125.8	133	246
3	54	4.1	2.0	0	0.8	0.5	107.5	90	210
4	186	6.0	2.0	0.3	1.6	2.0	92.6	310	181
5	11	1.2	1.2	0	0.4	0.1	87.6	18	171
6	154	4.5	2.5	0	1.5	1.8	87.2	257	171
7	168	6.2	4.0	0.5	2.0	3.1	53.5	280	105
8	24	2.3	1.5	0	0.8	0.5	47.8	40	93
9	20	1.5	1.0	0	0.8	0.5	39.8	33	78
10	31	2.3	1.5	0	1.0	0.8	39.5	52	77
11	25	2.2	1.5	1	0.9	0.6	39.3	42	77
12	66	12.0	2.0	0	1.5	1.8	37.4	110	73
13	35	3.3	1.9	0	1.1	0.9	36.8	58	72
14	99	6.0	2.0	0.5	2.0	3.1	31.5	165	62
15	12	4.0	2.0	0	0.8	0.5	23.9	20	47
16	9	2.5	2.0	0.4	0.7	0.4	23.4	15	46
17	31	5.0	1.6	0.5	1.4	1.5	20.1	52	39
18	30	4.5	2.0	0.4	1.7	2.3	13.2	50	26
19	33	5.0	1.7	0.7	1.8	2.5	13.0	55	25
20	22	3.5	1.7	0.5	1.7	2.3	9.7	37	19
21	14	4.4	1.4	0.4	1.7	2.3	6.2	23	12
	60 (96)	**4.1 (56)**	**1.8 (34)**	**0.3 (107)**	**1.3 (38)**	**1.4(68)**	**51.1(77)**	**100 (96)**	**100 (77)**

No. flowers/m^2 = No. flowers divided to crown area (m^2). Individual-based method = No. flowers divided to mean (60) * 100. Crown-area-based method = No. flowers/m^2 divided to mean (51.1) * 100. Bold figures are mean (coefficient of variation, %).

An average number of flowers were 60 flowers/tree/year and the average number of flowers/$m^2$was 51.1 (Table 1). By the individual-based method, there werenine of 21 trees with flower production of <50% population mean (Fig. 3). There were five trees with flower production 50-100% population mean, three trees with flower production= 100-200% population mean, and four trees with flower production>200% population mean (Fig. 3). By the crown-area-based method, there were seven of 21 trees with flower production of <50% population mean. There were seven trees with flower production 50-100%

population mean, four trees with flower production 100-200% population mean, and three trees with flower production>200% population mean (Fig. 3).

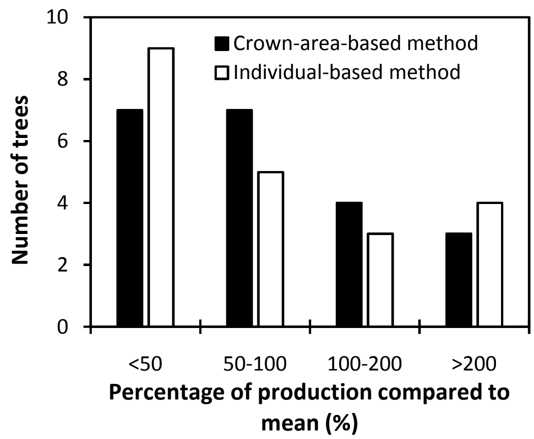

Fig. 3. A number of trees in different categories of productioncompared to the population mean

By the individual-based method, trees no. 12 and 14 had flower production>100% population mean (Table 1), but they had flower production<100% population mean by the crown-area-based method. While by crown-area-based method, there were two trees (trees no. 3 and 5) with flower production>100% population mean, but they had flower production<100% population mean by individual-based method (Table 1).

By the individual-based method, the lowest flower production tree achieved 15% population mean (Table 1), while the highest production tree achieved 310% population mean. By the crown-area-based method, the lowest flower production tree achieved 12% population mean (Table 1), while the highest production tree achieved 270% population mean (Table 1). The highest flower production tree (310% population mean, tree no. 4) by the individual-based method and that (270% population mean, tree no. 1) by the crown-area-based method were different. The similar pattern was for the lowest flower production tree (tree no. 16 by the individual-based method and tree no. 21 by crown-area-based method). There were only five similar trees having flower production>100% population mean by both methods including trees no. 1, 2, 4, 6, and 7 (Table 1).

4. DISCUSSION

The studied population of *C. impressinervis* was established personally by local people from trees which were dug up in natural forests and transplanted[9]. At the time of planting, trees were unknown ages and big, and trees hadflowered. After planting, they were not tending properly (e.g., no fertilization, watering). At the time of data collection in October 2018, there were some big trees (e.g., stump diameter of 4-5 cm, tree height of 1.8-2.5 m, and crown diameter of 1.3-1.5 m) without flowering. While there were some smaller trees flowering numerously. Interviewing indicated that no-flowering trees had never flowered. Such difference indicates that internal factors such as genetic difference controlling flowering capacity of *C. impressinervis* individuals. Therefore, selecting plus trees must be applied for a better flower-production plantation.

The selection of plus trees is the first step in improvement programs [6]. After selecting plus trees, adequate progeny tests should be conducted for superior genotypes by geneticists or they may be made by silviculturists with the advice and guidance of geneticists. However, ones may use stock plants of plus trees to establish plantations, which will have higher production than extensive plantations. Plus trees must have production higher than the population average [2]. However, how much higher/different from the mean is depending on selectors (e.g., plus 25%). For progeny tests, a large number of plus trees should be selected. While for immediate seedling production by vegetative propagation from plus trees, a smaller amount of plus trees should be selected. Since a large number of plus trees will have a large change to select the best trees in progeny tests. While a smaller number of plus trees will ensure more uniform and production of plantation established immediately from stock plants of plus trees.

For the best result of selecting plus trees, concerned populations must be mature as stability in flowering in the present study site and grown in homogenous conditions [17-19]. When a tree is mature, their growths on stem diameter, stem height, and crown diameter are negligible. Therefore, their flower production is also stable every year, if there are no considerable changes in surrounding environments (e.g., climate condition, edaphic) and tending conditions. There are two mature plus trees selected as mentioned in Fig. 2. Ones could establish plantation with tree B using planting density of 10,000 trees/ha, and other plantation with tree C using planting density of 5,000 trees/ha. Such different density comes from the difference of their mature crown (Fig. 2). The difference of planting density and flower production between trees B and C leads to higher total flower production in population with plus tree B than that in population with plus tree C. Even individual-basedproduction of plus tree C (1.5 kg/year) was higher than that of plus tree B (1 kg/year). Therefore, using the crown-area-based method of selecting plus tree seems better suitable than individual-based method as basing on individual-basedproduction. Keep in mind that, production of any crops is represented in the unit of tons/ha/year. Therefore, the crown area of crops must be included as smaller crown-area crops should be planted in higher density than larger crown-area crops. Only that planted trees can usegrowing space, nutrients, and energy efficiency to maximize production.

Two methods of selecting plus trees as mentioned in this study resulted in different plus trees (Table 1). Both methods resulted in seven trees with flower production >100% population mean. However, only five of them are similar trees (tree no. 1, 2, 4, 6, and 7). The most plus tree (crown area of 2 m^2 ranking second) by the individual-based method is ranking 4th by crown-area-based method (tree no. 4), and the second plus tree (crown area of 3.1 m^2 ranking first) by the individual-based method is ranking 7th by crown-area-based method (tree no. 7). These indicate the larger-sized tree seems to be excluded by the crown-area-based method as the size of the crown area is concerned in estimation. Therefore, in future plantation establishment from plus trees and/or superior genotypes the maximum crown size of selected trees must be included in determining planting density.

5. CONCLUSION AND RECOMMENDATION

In this study, amethod to select plus trees for flower purpose was described and named as the crown-area-based method. The method is based on the crown area and flower production of concerned trees to generate the surplus of production of the individual tree compared to the population mean. The results showed that seven individual trees had flower production >100% population mean and were selected as plus trees.

Materials from seven selected plus trees can now be used for vegetative propagation to produce uniform seedlings for intensive plantations. In the other way, it can be used for adequate progeny tests to select superior genotypes.However, techniques for vegetative propagation must be improved first for high efficiency. Since, plus trees are small and materials for propagation are limited.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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